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REPORT OF WIND TUNNEL TEST OF CORPS OBSERVATION CO-1 MODEL

(AIRPLANE SECTION, S. & A. BRANCH)

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Prepared by Engineering Division, Air Service
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REPORT OF WIND TUNNEL TEST OF CORPS OBSERVATION CO-1 MODEL.

A 1/36 scale model of the corps observation CO-1 airplane, designed by the Engineering Division, Air Service, was tested in the routine manner, lift, drag and moments being determined for a range of stabilizer settings of from $+2^\circ$ to -6° to the thrust line. The model had various changes made on it from time to time. These changes were made to get the proper downwash on the tail surfaces for longitudinal stability.

RESULTS.

With the model as modified the second time—that is, with the upper surface of the wing at the center section continuous and the cut-out at the bottom of the wing—the airplane will balance at 3° incidence with a tail setting of -2° .

DISCUSSION.

The model, as first submitted, had the center section cut away for 86 inches on the full scale airplane, which did away with the downwash influence of the wings on the tail. Since the span of the tail plane is 114 inches, only 28 inches of the tail is influenced by wing downwash. The airplane, in this case, would balance at $+2^\circ$ with a stabilizer setting of -8° to the thrust line, but would not be sufficiently maneuverable. In order to verify the downwash hypothesis, the center section of the wing was filled in with plasticene, the superstructure pilot's cabin and gunner's wing cut-out were carefully faired, and the gunner's cockpit was left undisturbed.

A test of the machine with the wing thus modified, with stabilizer settings of 0° and -2° , substantiates the downwash explanation. With a stabilizer setting of -2° , the machine would then balance at approximately $3\frac{1}{2}^\circ$, and further shows a marked improvement as far as maneuverability is concerned. An additional test was made with a stabilizer setting of 0° , with the wing filled in as before, but the gunner's wing cutaway left open. The results of the test were practically identical with those of the previous one in which the wing was completely filled in. This would indicate that the portion of the wing which was cut away for the gunner's vision did not appreciably affect the wing downwash, but the superstructure in conjunction with that portion of the wing cut away for the pilot's cabin and for increased vision were the dominating factors in affecting the downwash.

If the center of gravity is moved back 0.175 inch on the model or 6.3 inches on the full scale airplane, and the stabilizer set at -6° to the thrust line, the airplane will balance at approximately 4° and be highly maneuverable.

Since these changes were out of the question, the model was changed so that the wing had the cutaway on the lower surface instead of the upper. In this way the wing had a continuous upper wing contour, which would cause a downwash from the wings on to the tail surfaces.

The model was supported on its wing tip and tested with stabilizer settings of 0° , -2° , and -4° to the thrust line. The model will possess static longitudinal stability at all angles of attack with a tail plane setting of -4° to the thrust line and balance at 4° incidence if the center of gravity is shifted back 0.12 inch on the model or 4.3 inches on the full-size airplane. When allowance is made for full flight conditions, the airplane will balance at 3° if the center of gravity is shifted in accordance with the above recommendation.

In June another series of tests was run to determine the correct stabilizer setting for correct balance of the airplane. The downwash of the wings and body was determined by using the tail plane as an exploring plane. Four cases of downwash due to the wings and body were tested. One test of the downwash due to wings alone was made.

The five cases for the wings and body were:

Body in position:

1. Model as submitted.
2. Upper wing camber and gunner's cockpit faired.
3. Upper and lower wing camber and gunner's cockpit faired.
4. Lower wing camber faired, upper camber and gunner's cockpit unfaired.
5. Wing alone faired as for wing and body.

With reference to the curve (fig. 13), it is seen that the downwash angle of the original model (1) is increased over the entire range by filling in the upper camber at the center section; (2) the absence of an upper camber is responsible for the large negative tail setting required to balance this machine. It was shown by a previous test that for proper balance the tail setting should be -4° to the thrust line. A comparison of curves (1) and (2) show that if the center section had not been altered, i. e. if the contour of the upper camber had been preserved, the tail setting required for balance would have been 2° less or approximately -2° to the thrust line.

The downwash angle for the original model (1) is decreased but slightly by fairing in of the lower camber (4).

As was to be expected, alteration of the lower wing surface had less effect on the downwash than modification of the upper surface.

When both the upper and lower camber are faired at the center section (3) the downwash angle is decreased below the angle of maximum lift and increased above when compared with (2).

Cases (3) and (5) are identical except for the removal of the body and indicate that downwash is not influenced appreciably by the body except at and beyond the angle of maximum lift for the model.

The change in downwash due to alteration of the wing form at the center section of a machine is of importance. It would seem that no quantitative prediction can be made of the result of such changes on the downwash

angle. It is desirable, whenever possible, to maintain the full wing section for that portion of the span of a machine which influences the downwash. If visibility is to be obtained by a modification of wing contour, the lower wing surface should be altered to obtain the desired effect. When radical departures in the wing contour are made, as in the case of the CO-1, for reasons of visibility or balance, ordinary empirical methods for the prediction of downwash are of little avail.

The L/D of 7.99 is quite high for a model mounted on an end spindle.

The results are given in the following tables and curves.

Figure 14 shows the original CO-1 model and figure 15 shows the modified CO-1 with the cut-out transferred from the top to the bottom of the wing.

TABLE 1.—Original model, stabilizer 0° to T. L.

CASE A.

θ	L.	D.	L/D.	X.	Z.	M.
-4	-0.164	0.0565	-2.90	0.0449	-0.167	-0.107
-2	-.013	.0500	-.26	.....	.....	.....
0	+.144	.0490	+2.94	.0490	+.144	-.189
2	.305	.0539	5.66	.....	.....	.....
4	.442	.0613	7.21	+.0303	.445	-.259
6	.579	.0734	7.89	.....	.....	.....
8	.696	.0863	8.07	-.0112	.701	-.330
10	.808	.1055	7.66	.....	.....	.....
12	.896	.1301	6.88	-.0583	.903	-.440
14	.920	.1684	5.46	-.0590	.933	-.525
16	.901	.2198	4.09	-.0367	.926	-.613

TABLE 2.—Original model, wings filled.

CASE B.

θ	L.	D.	L/D.	X.	Z.	M c. g.	
						Stab. 0°.	Stab. -2°.
0	0.210	0.0402	5.23	0.040	0.210	-0.083	+0.037
4	.527	.0536	9.83	+.016	.529	-.130	-.008
8	.822	.0793	10.36	-.035	.824	-.190	-.070
12	1.101	.1186	9.29	-.113	1.103	-.276	-.155
14	1.179	.1395	8.45	-.151	1.177	.....	.....
16	1.223	.1695	7.22	-.175	1.222	-.400	-.294
18	1.090	.2700	4.04	-.081	1.120	.....	.....

θ = Angle {incidence} (with relation to T. L.).

L = Lift on model (pounds).

D = Drag on model (pounds).

X = Longitudinal force on model (pounds).

Z = Normal force on model (pounds).

M = Moment about c. g. (pounds/inches).

Tested at M. I. T., January and February, 1921. Velocity: 30 m. p. h.

Model $\frac{1}{8}$ scale.

TABLE 3.—Original model, wings filled and gunner's cut-away open.

CASE C.

θ	L.	D.	L/D.	X.	Z.	M.
0	0.180	0.0427	4.22	0.043	0.180	-0.085
4	.483	.0545	8.87	+.020	.486	-.138
8	.763	.0785	9.72	-.029	.766	-.206
12	1.028	.1139	9.03	-.103	1.026	-.291
14	1.113	.1359	8.20	-.138	1.113	.....
16	1.150	.1643	7.00	-.160	1.151	-.400
18	1.032	.2486	4.15	-.073	1.060	.....

TABLE 4.—Wing alone.

CASE D.

θ	L.	D.	L/D.	X.	Z.	M.
-4	-0.128	0.0383	-3.34	0.029	-0.131	.....
0	+.153	.0319	+4.80	.032	+.153	-0.107
+4	.430	.0448	9.60	+.015	.433	-.071
8	.674	.0668	10.07	-.028	.677	-.050
12	.865	.0987	8.77	-.083	.865	-.043
16	.888	.1723	5.15	-.081	.901	-.130

TABLE 5.—Original model, moment about c. g. (lbs./ins.).

CASE A.

[Stabilizer settings other than 0°.]

θ	Stab. 2°.	Stab. -2°.	Stab. -4°.	Stab. -5.9°.
-4	-0.184	-0.051	+0.001	+0.055
0	-.271	-.130	-.075	-.019
4	-.331	-.200	-.145	-.078
8	-.410	-.270	-.210	-.156
12	-.520	-.370	-.300	-.248
16	-.713	-.510	-.420	-.360

TABLE 6.—Original model (special test) Mar. 7, 1921.

CASE I.

i.	L.	D.	L/D.
4	-0.176	0.0568	-3.10
-2	-.026	.0485	-.54
0	.120	.0476	+2.52
+2	.280	.0515	5.44
4	.420	.0601	7.00
8	.672	.0851	7.90
12	.884	.1306	6.77
16	.889	.2143	4.15

CASE II.

[Triangular blocks removed.]

i.	L.	D.	L/D.
4	-0.167	0.0571	-2.93
-2	-.028	.0502	-.56
0	.109	.0505	+2.16
+2	.265	.0579	4.58
4	.391	.0675	5.79
8	.634	.0937	6.77
12	.852	.1335	6.38
16	.847	.2169	3.91

TABLE 7.—Modified model, elevators at 0° to tail plane.

θ	L.	D.	L/D.	X.	Z.
-4	-0.145	0.0594	-2.44	0.048	-0.149
-2	.002	.0510	+.09	.051	+.001
0	.156	.0491	3.18	.049	.156
+2	.322	.0531	6.07	.042	.324
4	.460	.0617	7.46	.029	.463
6	.592	.0748	7.92	.013	.595
8	.721	.0903	7.99	-.011	.725
10	.838	.1092	7.67	-.038	.844
12	.961	.1356	7.18	-.069	.968
14	1.055	.1576	6.69	-.103	1.063
16	1.140	.1884	6.05	-.125	1.149
18	1.147	.2315	4.96	-.134	1.162

θ = Angle of thrust line to wing.

L = Lift on model, in pounds.

D = Drag on model, in pounds.

X = Longitudinal force on model, in pounds.

Z = Normal force on model, in pounds.

M = Moment about c. g., in pounds/inches.

Tested at M. I. T., April 15, 1921.

Velocity: 30 m. p. h.

Tail plane settings referred to thrust line.

TABLE 8.—*Modified model (complete, minus tail).*

θ	L.	D.	L/D.	X.	Z.	M c. g.
-4	-0.095	0.0558	-1.70	0.0491	-0.0985	-0.1859
-2	+ .064	.0492	+1.20	.0513	+ .0622	- .1471
0	.214	.0496	4.11	.0507	.2140	- .1011
+2	.378	.0553	6.84	+ .0431	.380	- .0717
4	.505	.0652	7.75	+ .0298	.508	- .0389
8	.758	.0944	8.03	- .0121	.765	- .0005
12	.974	.1367	7.12	- .0687	.982	+ .0207
16	1.131	.1884	6.00	- .1320	1.140	+ .0146
20	.887	.3239	2.74	.0000	.945	- .0830

TABLE 9.—*Modified model, M c. g. for tail plane settings.*

θ	0°	-2°	-4°	-4° c. g. shifted 0.12 inch back.
4	-0.072	-0.029	+0.045	+0.027
-2	-.098	-.058	+ .020	+ .020
0	-.124	-.081	+ .009	+ .018
+2	-.155	-.115	- .029	+ .010
4	-.188	-.132	-.055	+ .000
6	-.219	-.160	-.060	- .009
8	-.254	-.200	-.126	-.039
10	-.306	-.255	-.178	-.067
12	-.345	-.297	-.222	-.106
14	-.395	-.352	-.278	-.150
16	-.446	-.422	-.342	-.204
18	-.561	-.503	-.412	-.273

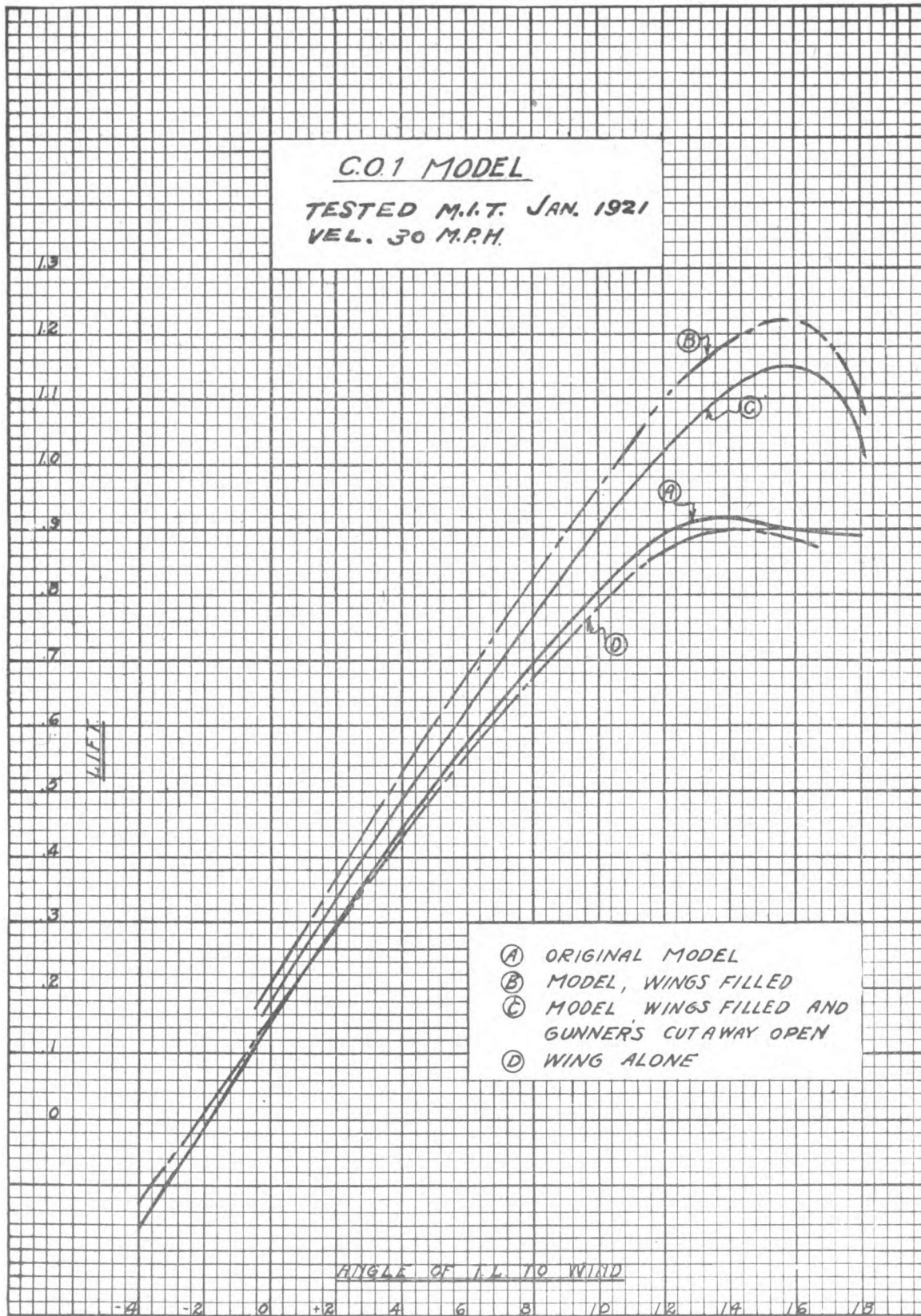


FIG. 1.

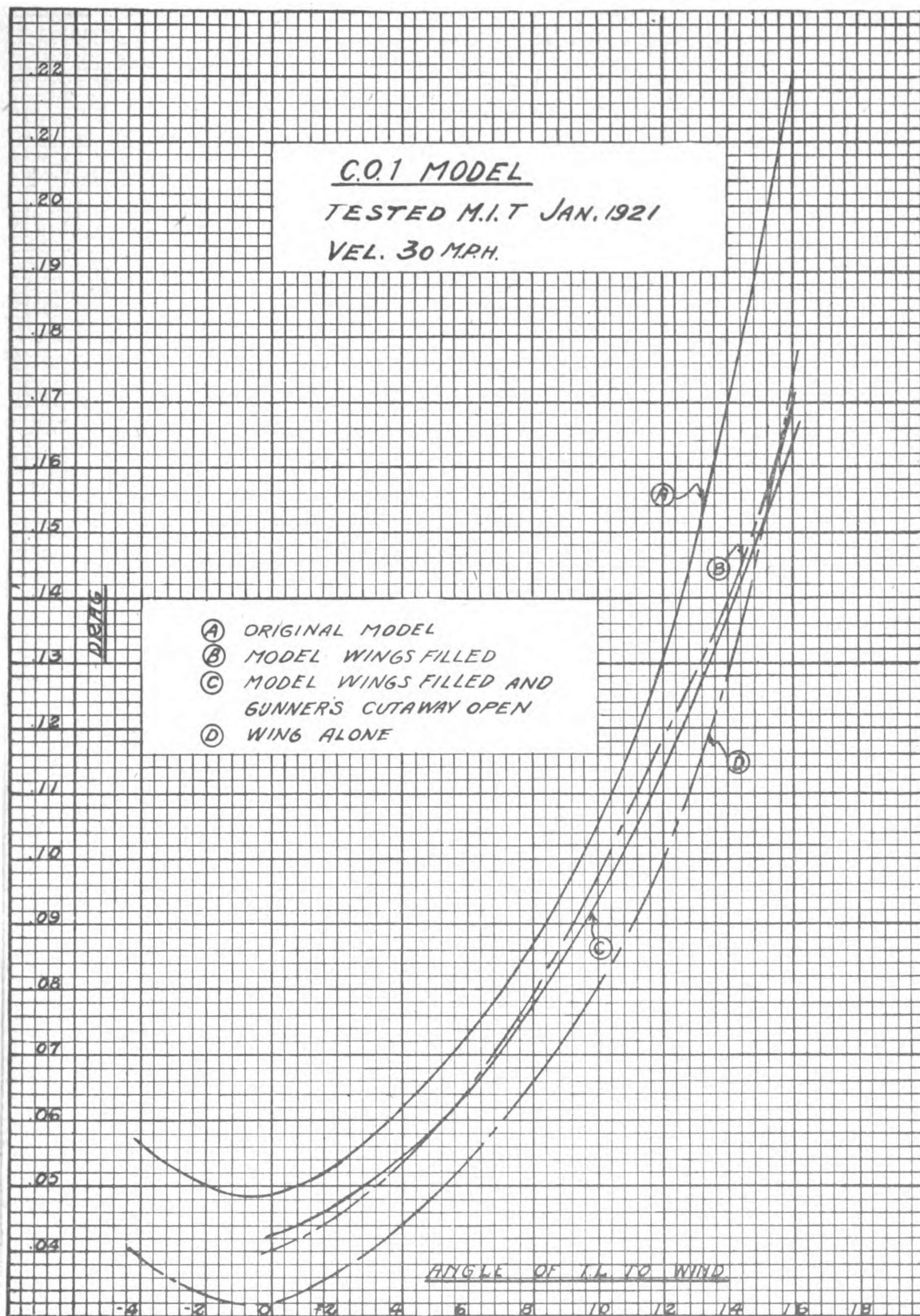


FIG. 2.

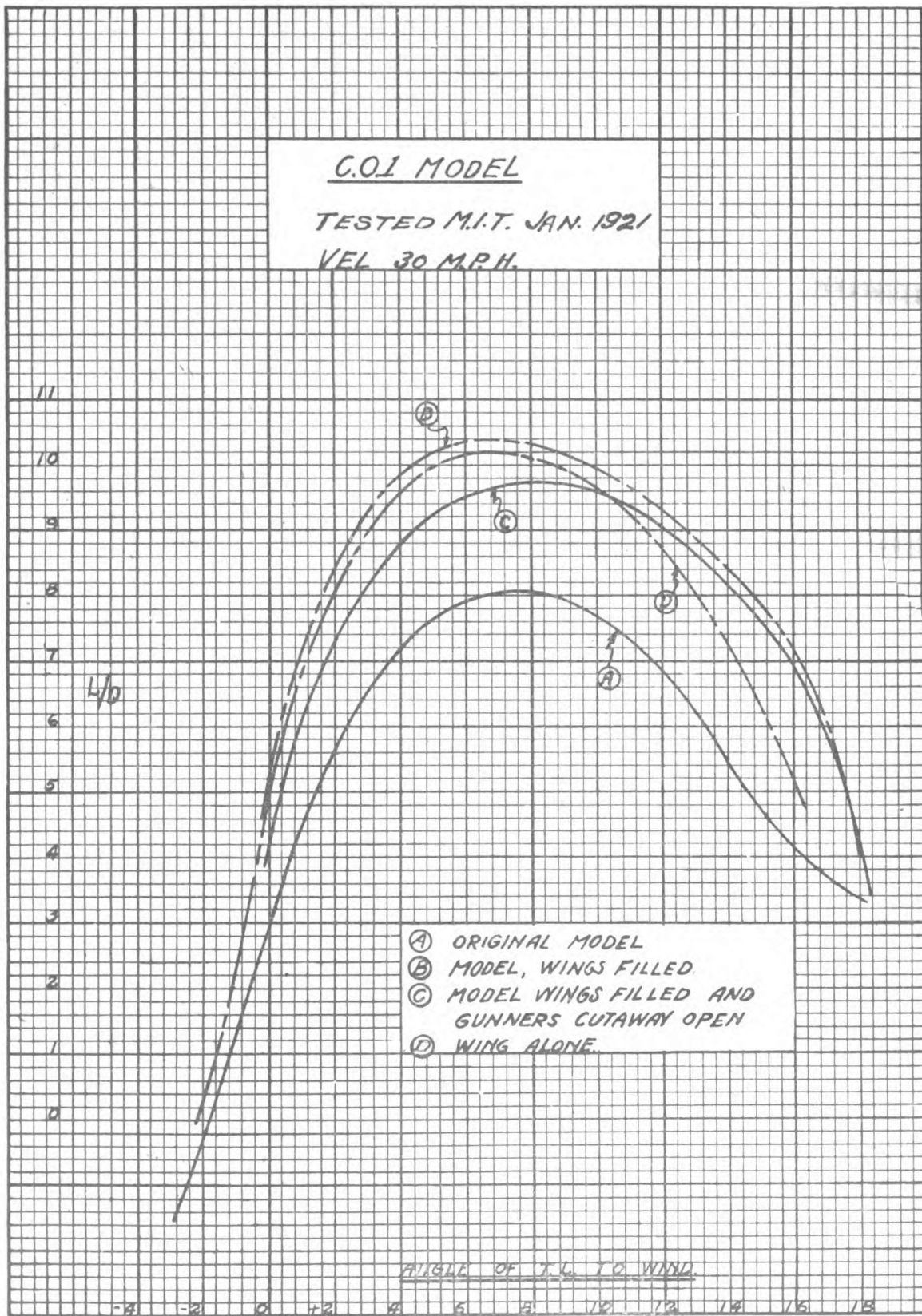
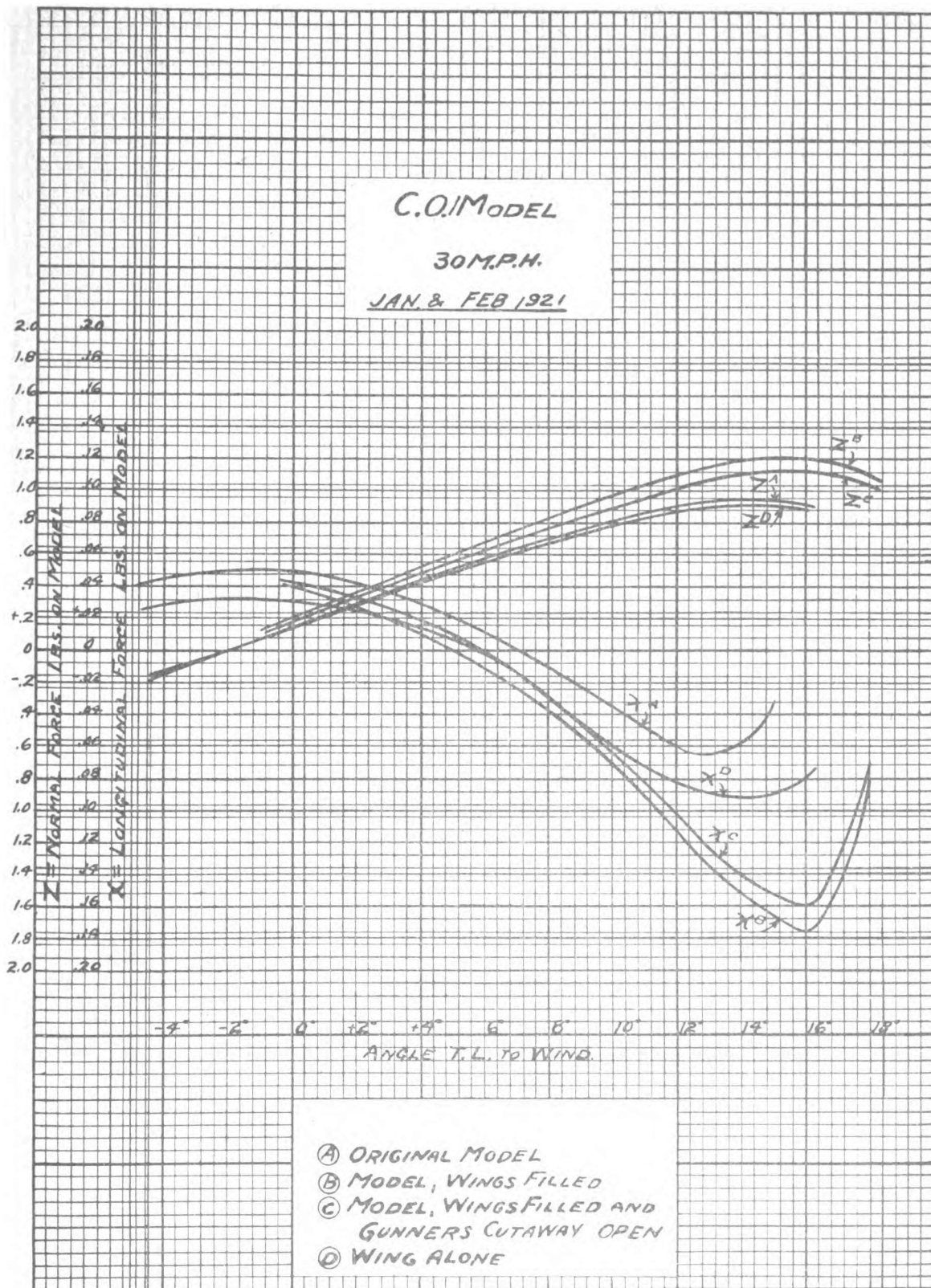


FIG. 3.



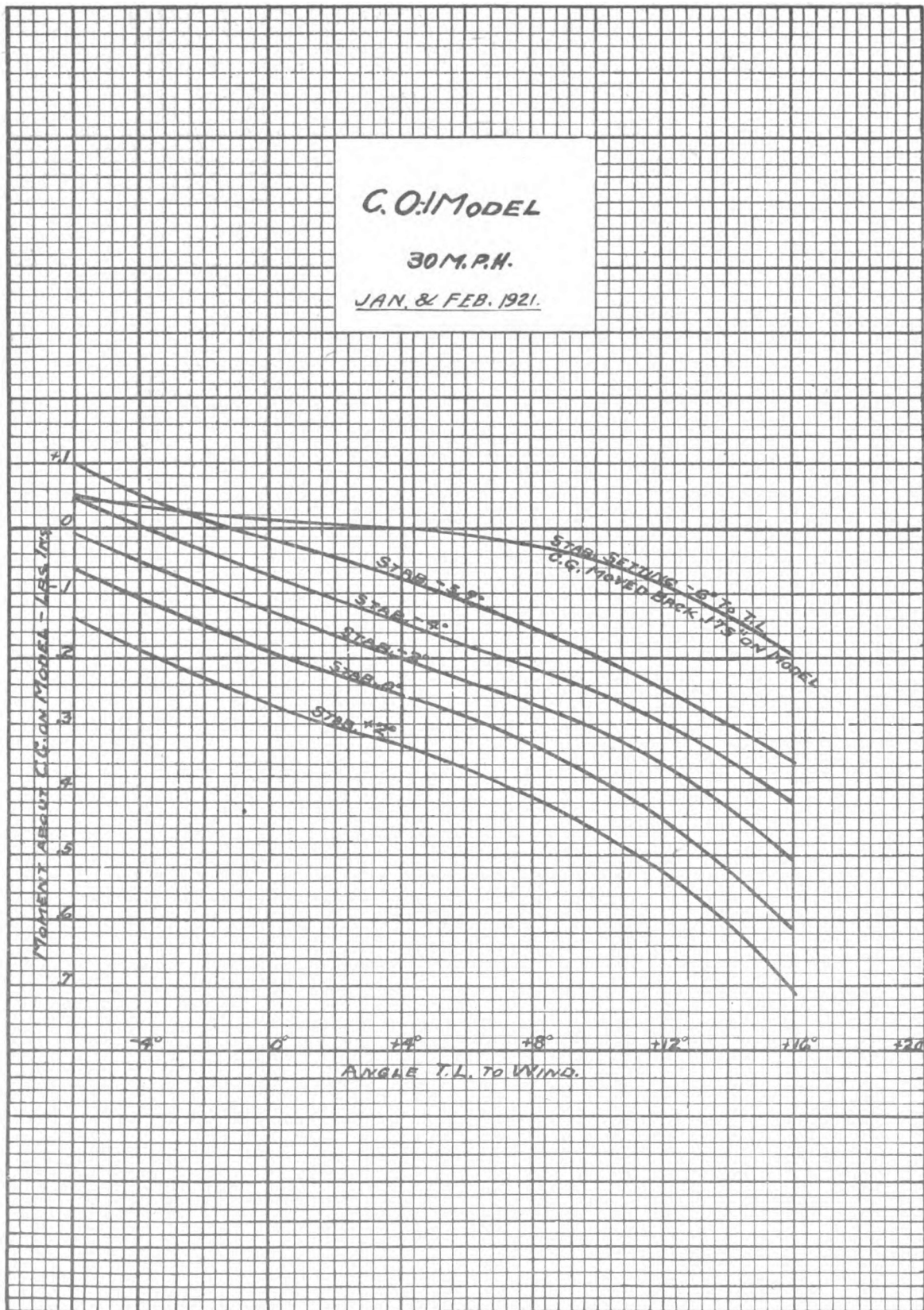


FIG. 5.

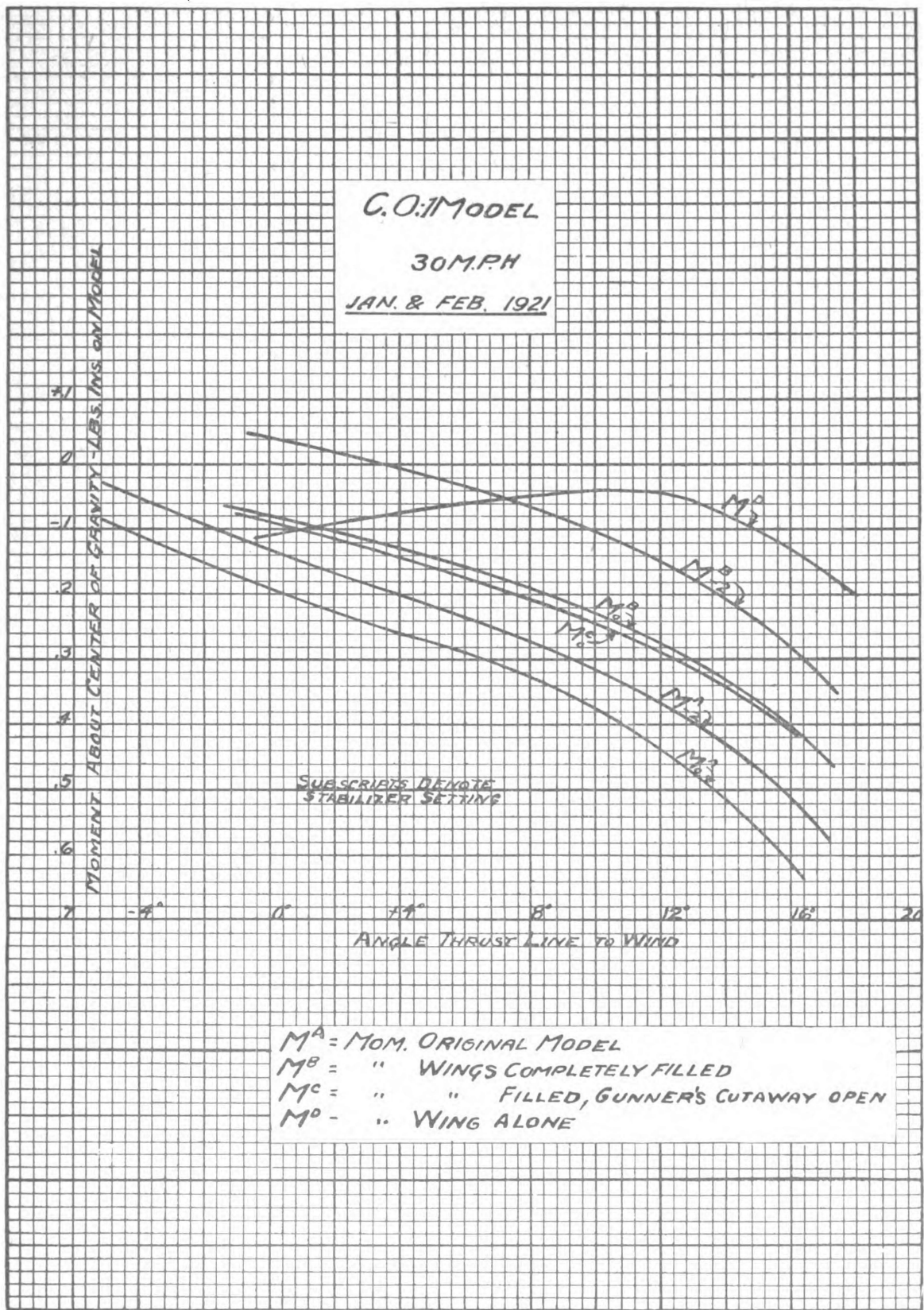


FIG. 6.

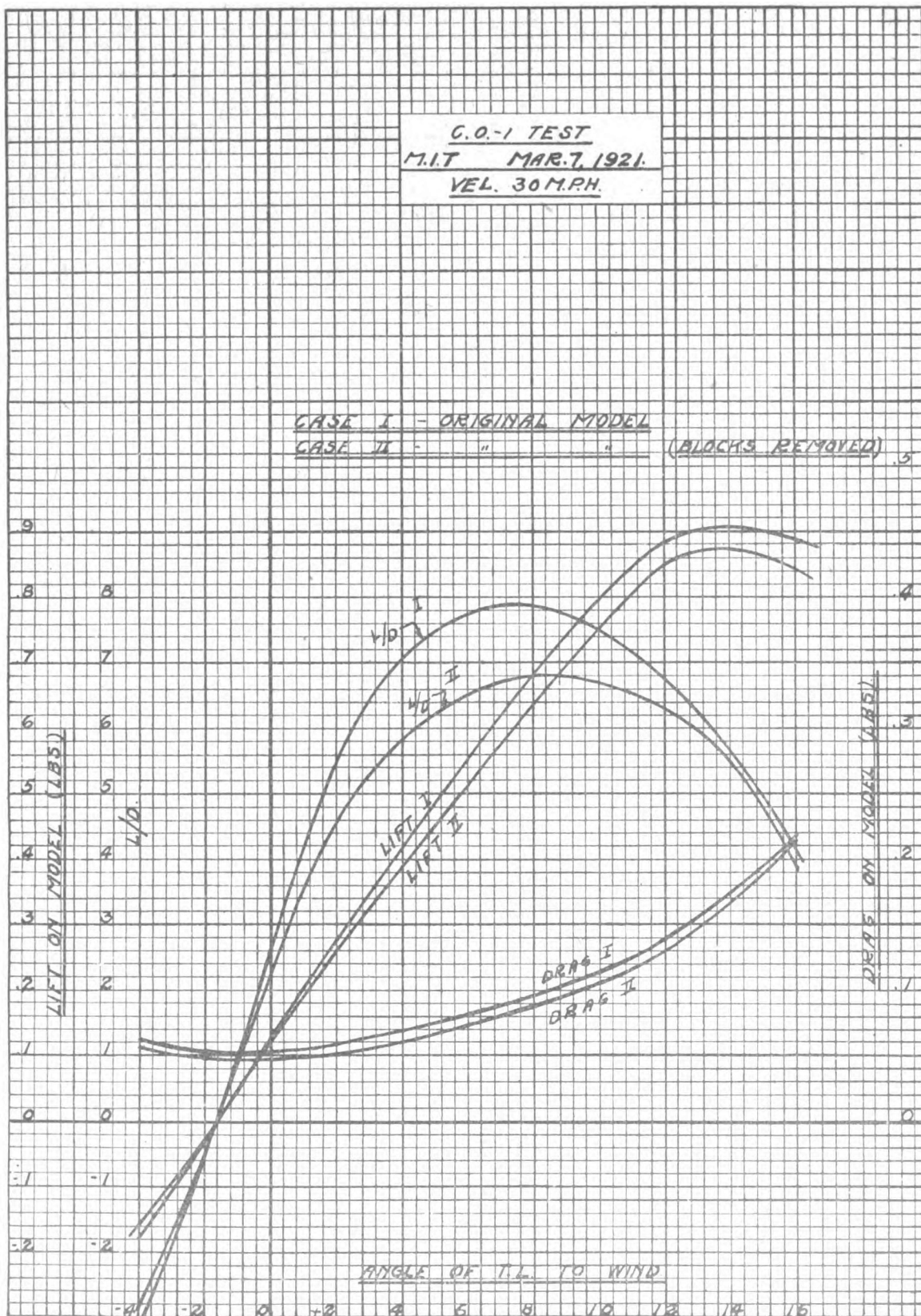


FIG. 7.

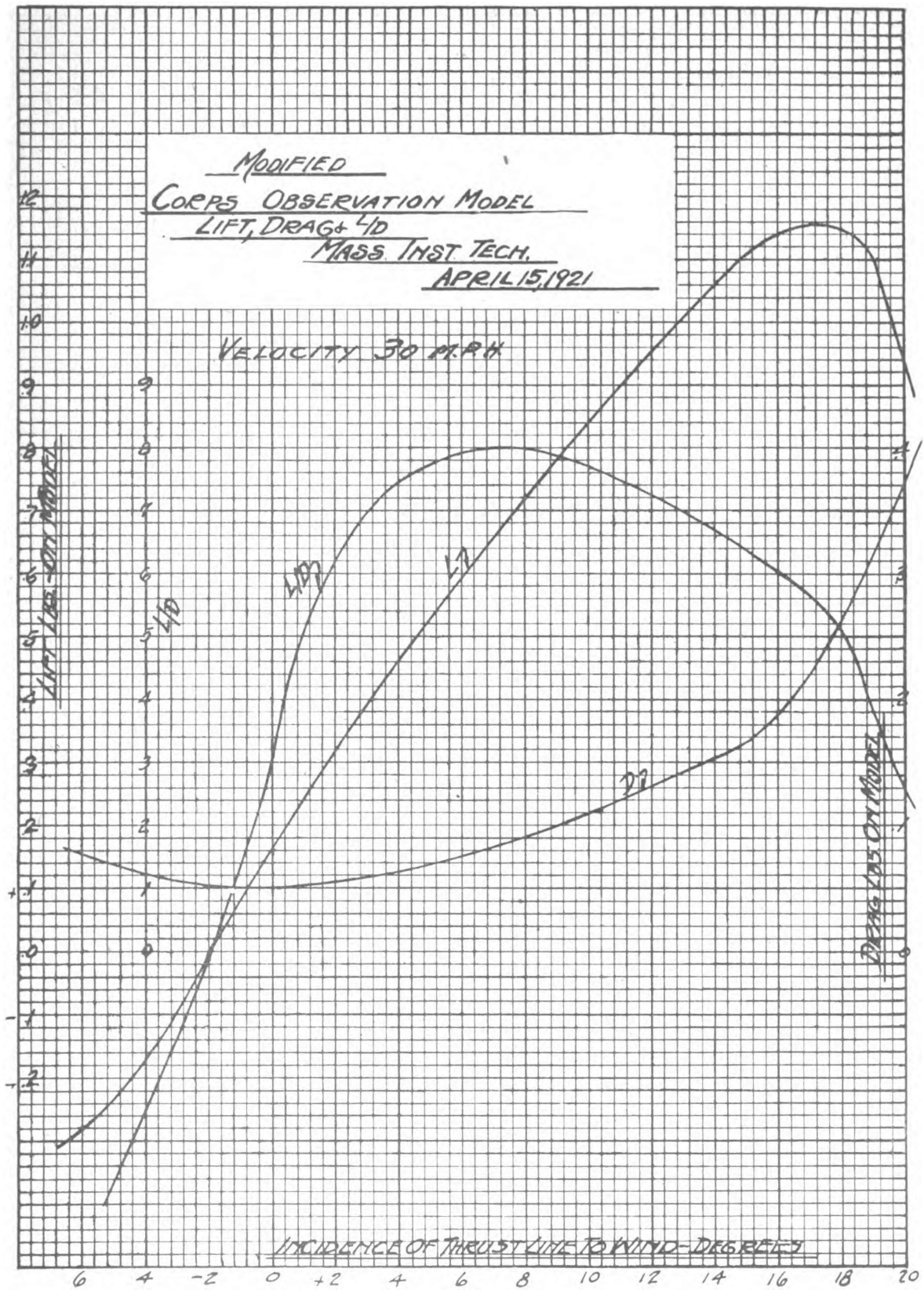


FIG. 8.

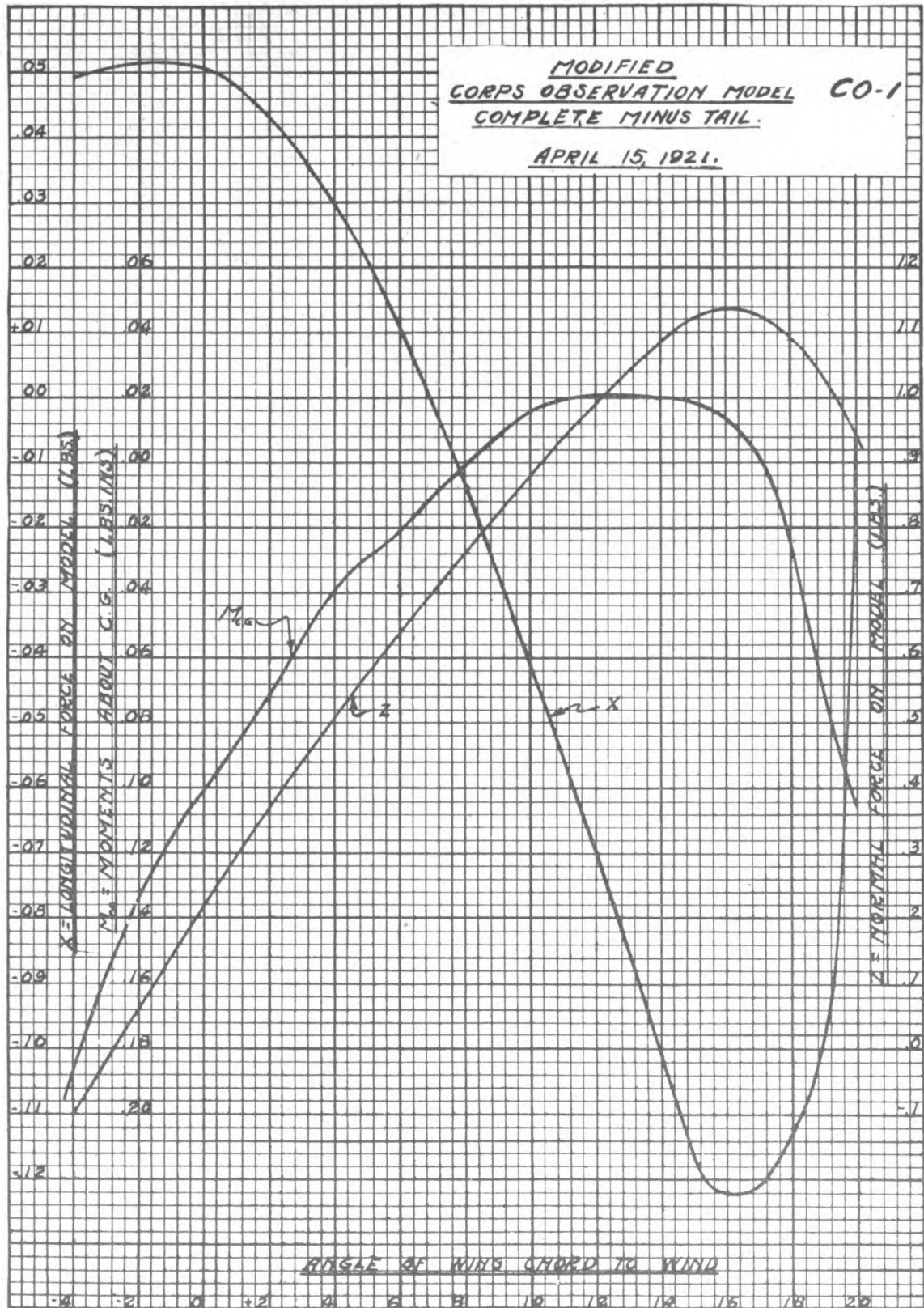


FIG. 9.

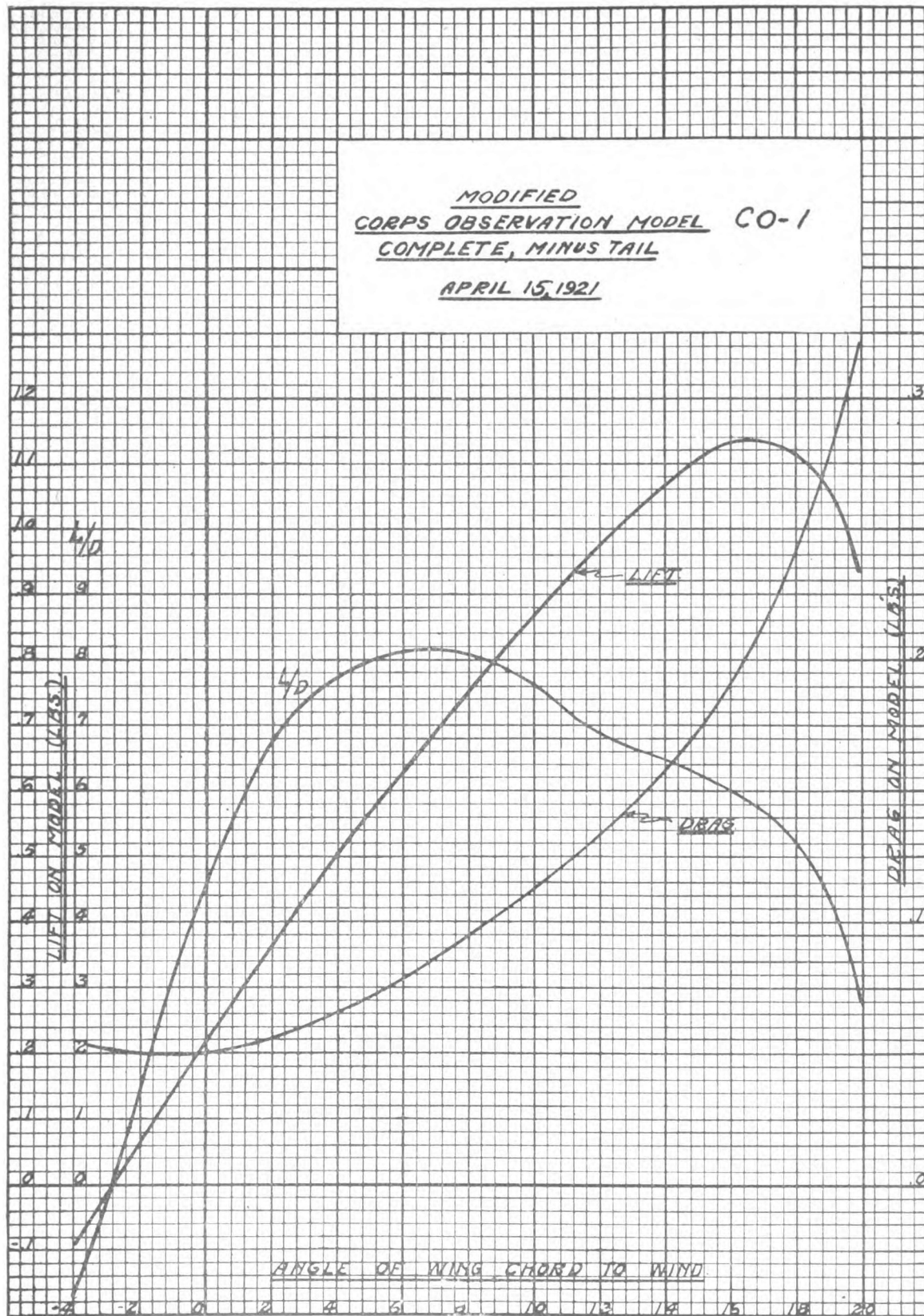


FIG. 10.

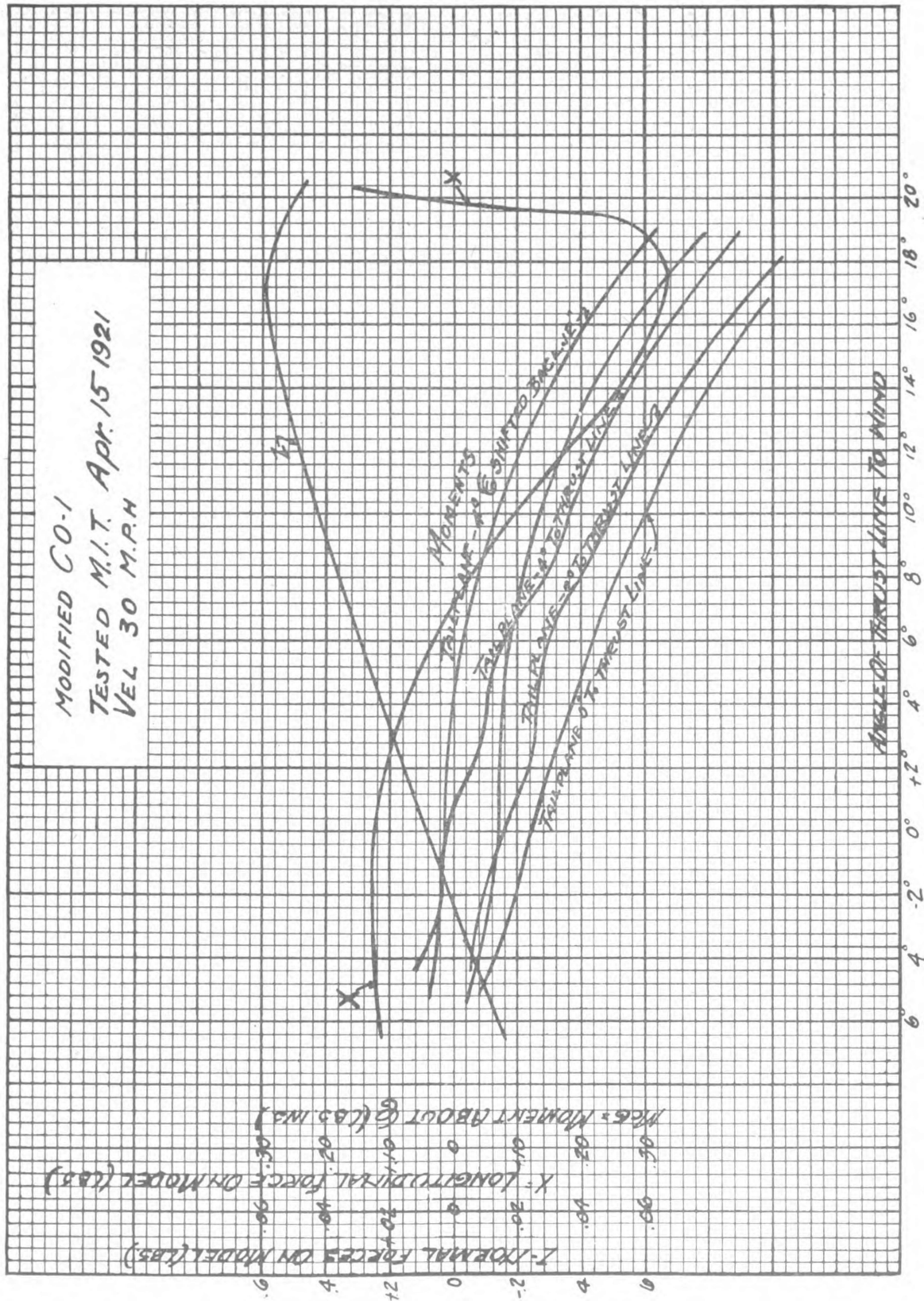


FIG. 11.

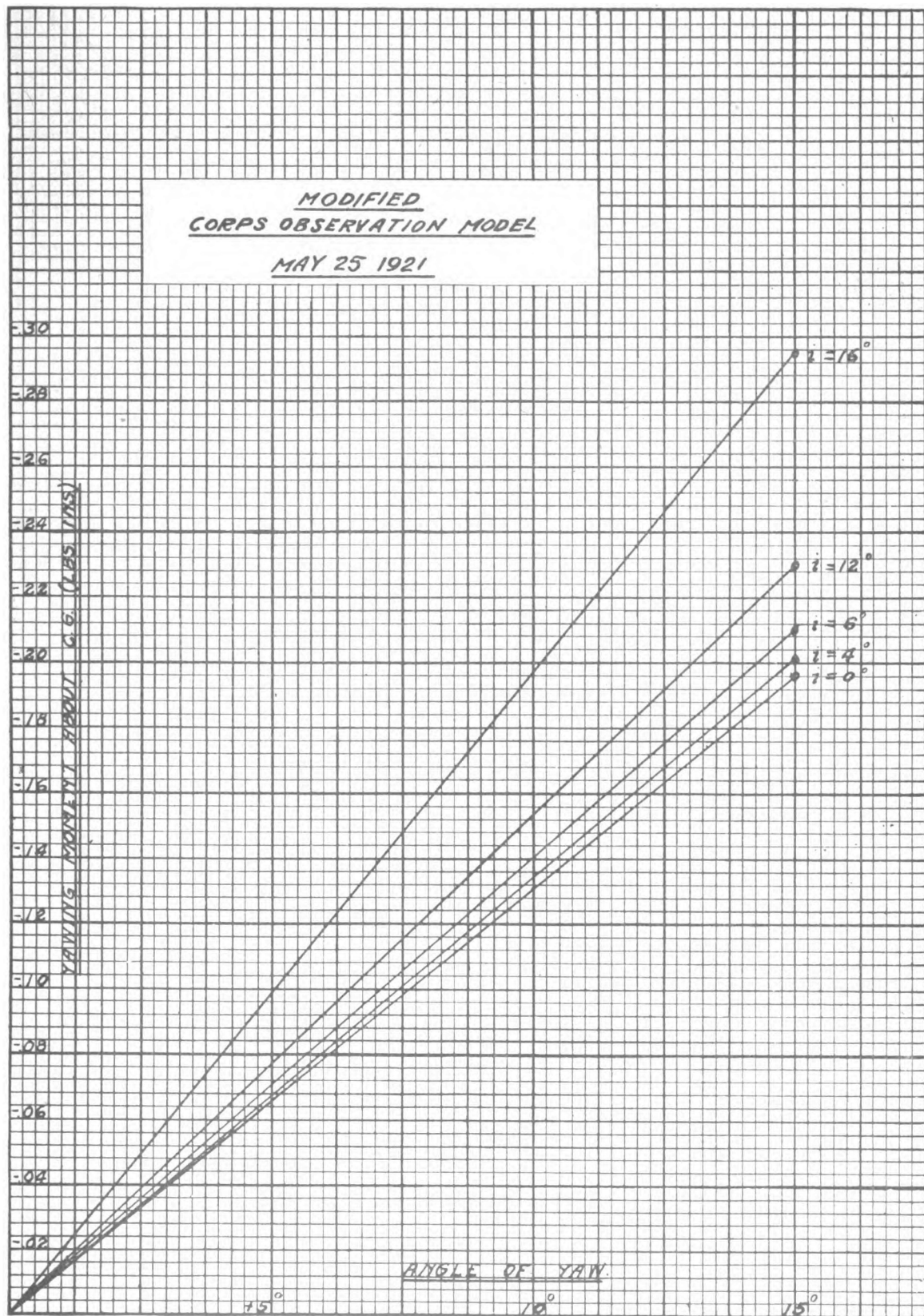


FIG. 12.

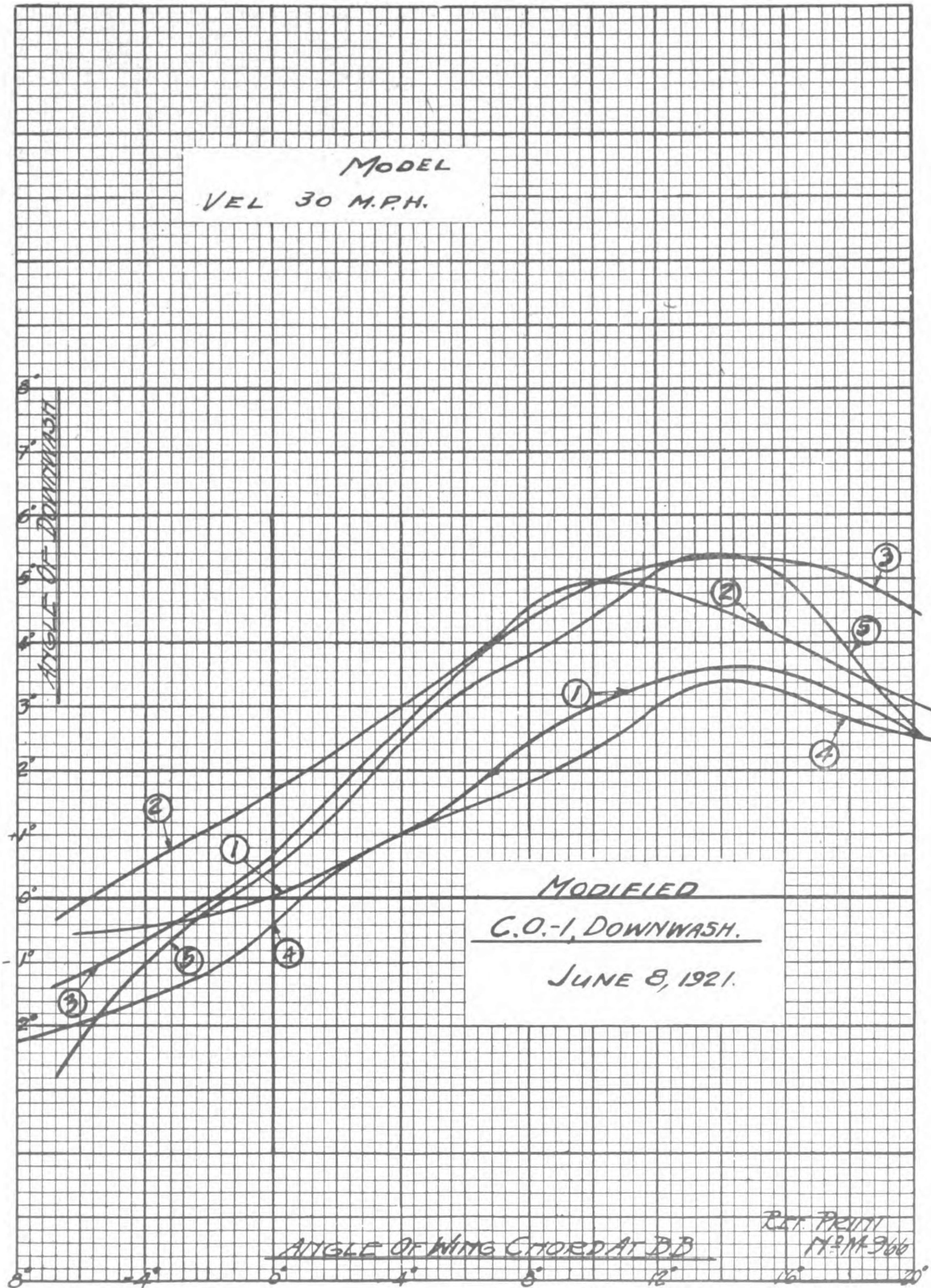
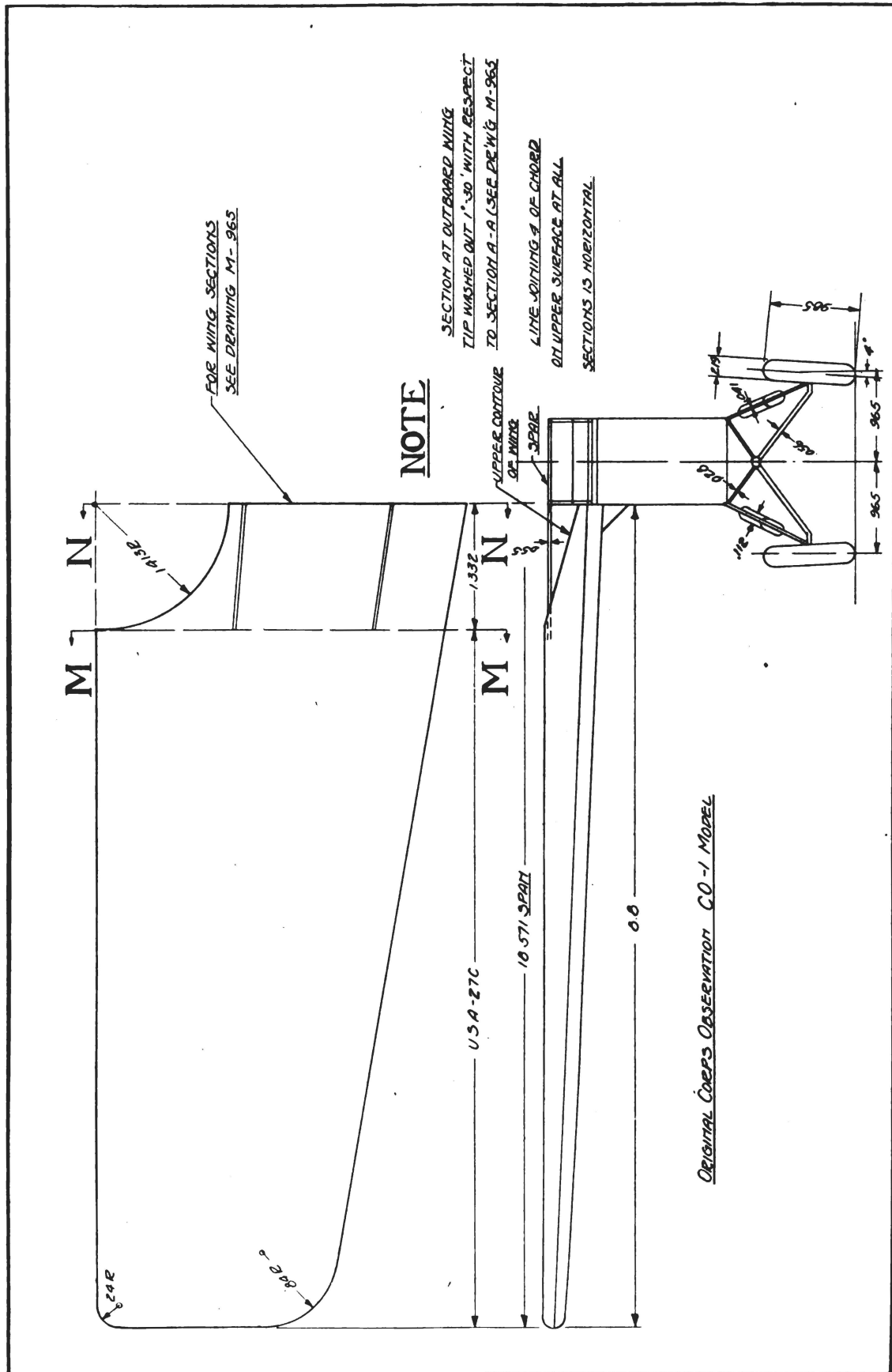


FIG. 13.



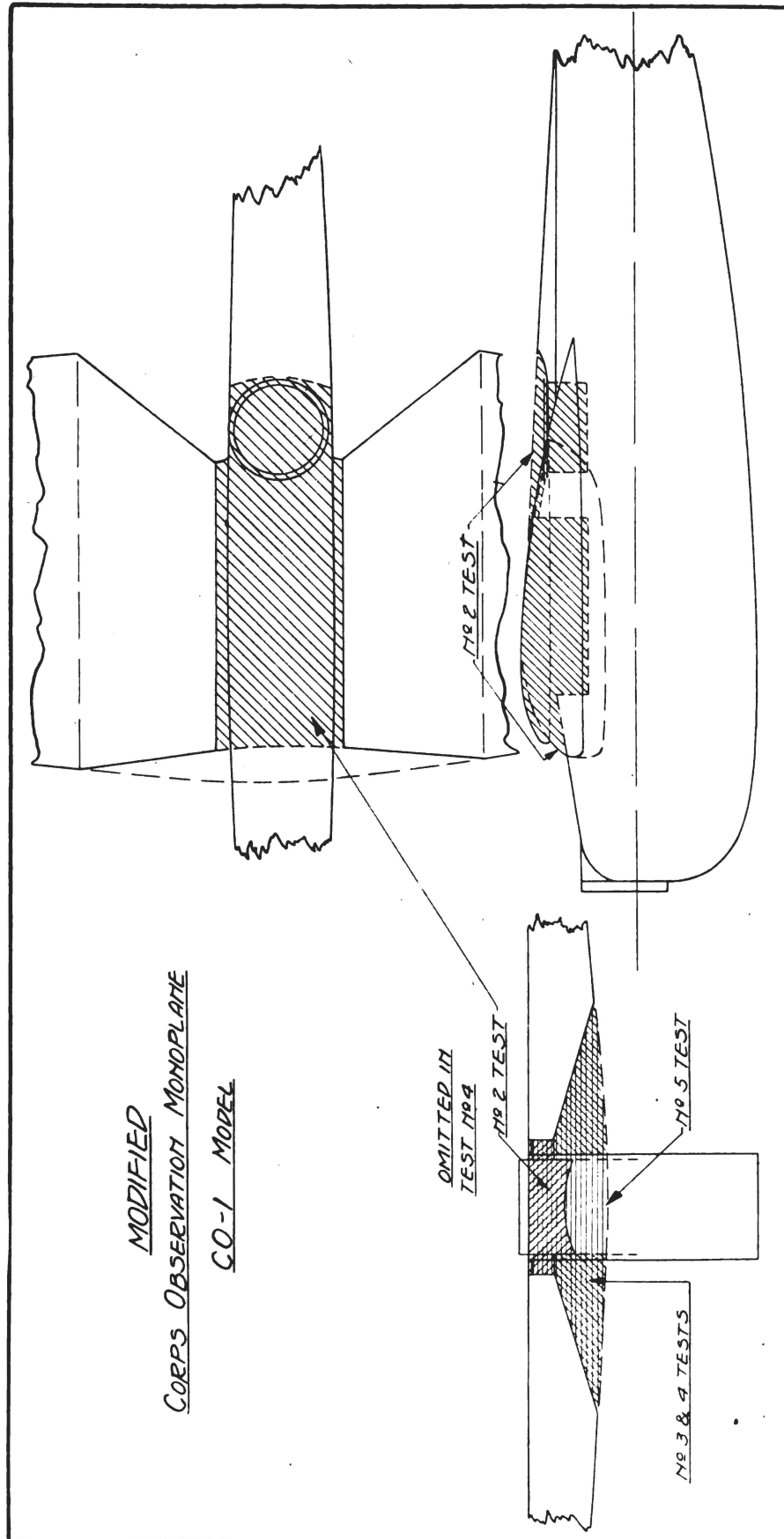


FIG. 15.